Available online at www.sciencedirect.com
SCIENCE DIRECT
Preventive Medicine 38 (2004) 628–636
Preventive Medicine
www.elsevier.com/locate/ypmed

Self-efficacy partially mediates the effect of a school-based physical-activity intervention among adolescent girls

Rod K. Dishman, Ph.D.,[a,*] Robert W. Motl,[a] Ruth Saunders,[b] Gwen Felton,[c] Dianne S. Ward,[d] Marsha Dowda,[e] and Russell R. Pate[e]

[a] Department of Exercise Science, University of Georgia, Athens, GA 30602-6554, USA
[b] Department of Health Promotion and Education, University of South Carolina, Columbia, SC 29208, USA
[c] College of Nursing, University of South Carolina, Columbia, SC 29208, USA
[d] School of Public Health, University of North Carolina, Chapel Hill, NC 27599, USA
[e] Department of Exercise Science, University of South Carolina, Columbia, SC 29208, USA

Abstract

Background. This study evaluated the effects of the Lifestyle Education for Activity Program (LEAP), a comprehensive school-based intervention emphasizing changes in instruction and school environment, on variables derived from social-cognitive theory (SCT) as mediators of change in physical activity among black and white adolescent girls.

Methods. Twenty-four high schools paired on enrollment size, racial composition, urban, suburban, or rural location, and class structure were randomized into control (n = 12) or experimental (n = 12) groups. There were 1038 girls in the control group and 1049 girls in the experimental group. The multicomponent intervention emphasized the enhancement of self-efficacy and development of behavioral skills by using curricular activities within physical education classes and health education instruction. The primary outcomes were self-efficacy, outcome-expectancy value, goal setting, satisfaction, and physical activity.

Results. Latent variable structural equation modeling indicated that: (1) self-efficacy and satisfaction exhibited synchronous, cross-sectional relationships with physical activity; (2) the intervention had direct effects on self-efficacy, goal setting, and physical activity; and (3) self-efficacy partially mediated the effect of intervention on physical activity.

Conclusions. To our knowledge, this study provides the first evidence from a randomized controlled trial that manipulation of self-efficacy results in increased physical activity among black and white adolescent girls. The results encourage the use of self-efficacy as a targeted, mediator variable in interventions designed to increase physical activity among girls.

Keywords: African American; Behavior modification; Exercise; Randomized controlled trial; Social cognitive theory; Latent variable structural equation modeling

Introduction

Physical inactivity is prevalent among the youth in the United States, particularly among adolescent girls [1], and it is presumed to be a public health burden [2] that requires the development of successful interventions to increase physical activity [3]. Previous physical activity interventions have been weakly effective among the youth [4,5], probably because they failed to adequately focus the intervention on theoretically based mediators of physical activity [6,7]. A potentially more successful approach to physical activity interventions involves targeting social-cognitive variables that are correlates of physical activity and are putative influences on volitional behavior [8–10]. Social-cognitive variables include personal beliefs that are sensitive to both reinforcement history and social influence. Hence, they warrant study as mediators of physical activity, which increasingly becomes a leisure choice as American youth enter adolescence.

Social-cognitive theory (SCT) [11,12] was derived from expectancy value and social learning theories [13–16] and proposes that personal, environmental, and behavioral factors operate as reciprocal, interacting determinants of each

* Corresponding author. Department of Exercise Science, The University of Georgia, Ramsey Student Center, 300 River Road, Athens, GA 30602-6554. Fax: +1-706-542-3148.
E-mail address: rdishman@coe.uga.edu (R.K. Dishman).

0091-7435/$ - see front matter © 2004 The Institute For Cancer Prevention and Elsevier Inc. All rights reserved.
doi:10.1016/j.ypmed.2003.12.007

other. Thus, physical activity behavior is considered within a dynamic, interacting causal system. Within the causal system, SCT identifies cognitive processes as key mediators between external stimuli, such as an intervention, and behaviors, such as physical activity. Cognitive processes presumably influence an individual's ability to control physical activity and its determinants (i.e., personal, environmental, and behavioral factors). Primary cognitive processes included within SCT are self-efficacy, outcome-expectancy value, goal setting, and satisfaction [11,12]. According to SCT, those cognitive processes are reciprocally interrelated and would have direct effects on physical activity, as depicted in Fig. 1. Individuals who are dissatisfied with their current physical activity level and who have positive outcome-expectancies about physical activity, adopt challenging goals, and believe they have the ability to attain their goals (i.e., self-efficacy), would presumably have optimal motivation for adopting and maintaining physical activity.

Some of the cognitive processes within SCT (i.e., self-efficacy and outcome-expectancy value) have been identified as correlates of physical activity among children and adolescents [17,18]. We previously reported that self-efficacy was the primary correlate of moderate and vigorous physical activity in a large sample of adolescent girls and accounted for their intentions to be physically active [18]. However, we are unaware of research that has examined the relationships among self-efficacy, outcome-expectancy value, goal setting, satisfaction, and physical activity as specified by SCT among the youth. Moreover, none of the relationships posited by SCT has been examined by a randomized controlled trial of a physical activity intervention among adolescent girls.

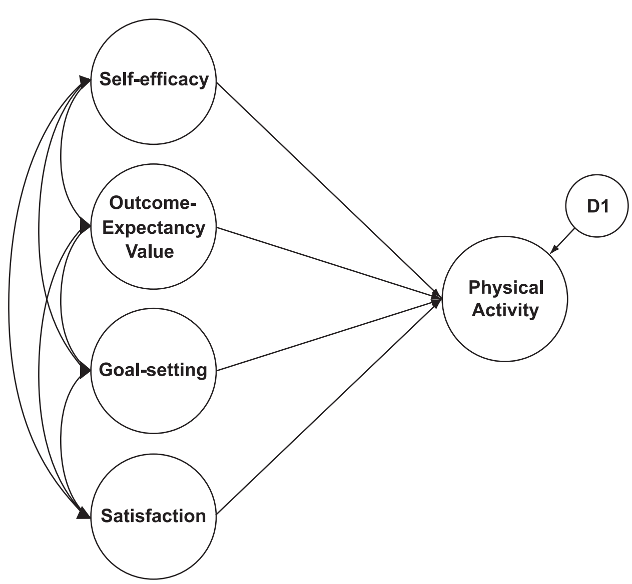

Fig. 1. Theoretical model depicting reciprocal interrelationships and direct effects of primary cognitive processes included within social cognitive theory on physical activity. D1 represents disturbance term.

The present study evaluated the effects of the Lifestyle Education for Activity Program (LEAP), a school-based intervention to increase physical activity and fitness among adolescent black and white girls, on hypothesized changes in cognitive constructs from SCT (i.e., self-efficacy, outcome-expectancy value, goal setting, and satisfaction) and physical activity. The effect of the intervention was tested using latent variable structural equation modeling (LVSEM) which permits simultaneous estimation of the relationships among multiple predictor, intervening, and outcome latent variables by parameter estimates that are not biased by measurement error and are independent of the other latent variables in the model.

Methods

Participants and study design

Participants were recruited from 24 high schools and their associated middle schools in South Carolina. The high schools were randomly selected from 54 of the 214 schools within the 91 school districts of South Carolina that were eligible and willing to participate in a school-based intervention to increase physical activity and fitness. High school eligibility was based on two criteria: (1) number of 9th grade girls per school and (2) an approximately equal mix of black and white girls in the school. Girls in the 8th grade at middle schools that fed the selected high schools were then recruited for the baseline measurement and enrollment into the study. Among the 2841 girls who consented to be in the study, 2744 (97%) participated in measurement at the baseline, and 2087 of those girls (76%) were also measured at follow-up in the 9th grade.

To ensure that the intervention and control schools were comparable at baseline, the schools were paired according to enrollment size, percent of African American girls, urban, suburban, or rural location, and class structure (60- or 90-min classes). Schools from each pair were then randomized into intervention (n = 12) or control (n = 12) conditions. Baseline measures were administered during the spring of the girls' 8th grade year. The LEAP intervention was implemented throughout the 9th grade year, and outcome measures were taken during the spring of that year.

There were 4044 girls enrolled and eligible in the 24 high schools, and 51.6% of the girls participated in the measurement component of the study (N = 2087). There were 1038 girls in the control schools and 1049 girls in the intervention schools. The sample initially had a mean age of 13.6 years (SD = 0.6) and a body mass index (BMI) of 23.07 kg/m^2 (SD = 5.48). The racial proportions were 50.2% African American, 46.1% White, and 3.7% other. The control and experimental groups did not significantly differ in age, t (1,776) = 0.37, P = 0.71, BMI, t (1,671) =

0.30, $P = 0.76$, or distribution of race, χ^2 (2, N = 1,773) = 0.75, $P = 0.69$.

A comprehensive process evaluation was used to divide the 12 LEAP intervention schools into two groups: high ($n = 7$) and low ($n = 5$) implementers, for the purpose of defining the intervention variable included in the statistical analyses.[1] Four sources of process evaluation data were used to determine each school's level of implementation of the intervention components: the independent process evaluator's record review (documentation of all intervention elements), the independent process evaluator's observation of physical education classes, LEAP criteria total (LEAP staff ratings of implementation of all LEAP components), and adherence to LEAP criteria for LEAP physical education (LEAP staff ratings of implementation of LEAP PE). Ratings for those criteria were obtained using 3- or 4-point ordinal scales (e.g. 3 = full implementation, 0 = no effort to implement). There were no differences at baseline between the high and low implementation groups in age, t (920) = 0.52, $P = 0.61$, or BMI, t (862) = 0.67, $P = 0.50$. The distribution of race differed, $\chi^2(2, N = 921) = 40.28$, $P < 0.0001$; there were more black girls in the high implementation schools than in the low implementation schools, but the number of white girls was the same.

Measures

We have described elsewhere the development and psychometric properties of the measures of outcome-expectancy value and self-efficacy about physical activity [19,20]. The measures conformed to unidimensional models that were factorially invariant between black and white girls and across time. The measure of outcome-expectancy value included eight items that consisted of belief and corresponding value statements. Belief statements were rated on a 5-point scale anchored by 1 (Disagree a lot) and 5 (Agree a lot). Value statements were rated on a 5-point scale with responses ranging from 1 (Very bad) to 5 (Very good). The outcome-expectancy value items were formed as a product of the belief and corresponding value item scores [21]. The measure of self-efficacy consisted of eight items rated on a 5-point scale ranging from 1 (Disagree a lot) to 5 (Agree a lot).

The measures of goal setting and satisfaction about physical activity included six items and one item, respectively. The goal setting items included the common stem of *A goal of mine now is to be physically active so I can* and the items were (1) deal with stress; (2) have fun; (3) be more muscular; (4) keep in shape; (5) increase my energy; and (6) be better in other physical activities. The goal setting items were best described by a unidimensional model based on an initial confirmatory factor analysis with baseline data from this sample ($\chi^2 = 18.60$, df = 9, RMSEA = 0.023 [90% CI = 0.007–0.037], CFI = 0.994, NNFI = 0.989). The satisfaction item was: I am happy with the amount of physical activity I get now. The items were rated on a 5-point scale with anchors of 1 (Disagree a lot) and 5 (Agree a lot).

Physical activity was assessed using the 3-Day Physical Activity Recall (3DPAR), which is a modification of the Previous Day Physical Activity Recall [22]. We selected the 3DPAR because it assesses multiple days of physical activity in a single reporting session and is well suited for school-based studies where student access is limited to one or two class periods. Assessing physical activity over multiple days also provides a reliable estimate of usual physical activity. The 3DPAR required participants to recall physical activity behavior from three previous days of the week (first Tuesday, then Monday, then Sunday); the instrument always was completed on Wednesday. Those 3 days were selected to capture physical activity on one weekend day and two weekdays. To improve the accuracy of physical activity recall, the 3 days were segmented into thirty-four 30-min time blocks, beginning at 7:00 AM and continuing to 12:00 AM. To further aid recall, the thirty-four 30-min blocks were grouped into broader time periods (i.e., before school, during school, lunchtime, after school, suppertime, and evening). The 3DPAR included a list of 55 commonly performed activities grouped into broad categories (i.e., eating, work, after school, spare time, hobbies, transportation, sleeping, bathing, school, and physical activities and sports) to improve activity recall; this was not a checklist, but rather a mnemonic device. For every one of the thirty-four 30-min time blocks, students reported the main activity performed and then rated the relative intensity of the activity as light, moderate, hard, or very hard. To help students select a relative intensity, the instrument included illustrations depicting activities representative of the various intensities. The data then were converted into blocks of total METs (i.e., physical activity level expressed as multiples of basal metabolic rate) for each day. The validity of the 3DPAR has been established based on correlations with a self-report measure of sport involvement [23] and an objective measure of physical activity derived from accelerometry [24].

Procedures

The procedures were approved by the University of South Carolina Institutional Review Board, and all participants and the parent or legal guardian provided written informed consent. The measures were administered to participants in groups of 6–10 girls by trained data collectors in the Spring semesters of 1999 and 2000 when students were in the 8th and 9th grades before and after the girls participated in the intervention and control conditions.

Intervention

LEAP was a comprehensive school-based, 2-year intervention that emphasized changes in instruction and the school environment.[1] It was designed to increase physical activity in high school girls by creating a school environment that supported the unique physical activity needs and interests of adolescent girls. The intervention adopted a social ecological model that emphasized key features of Social Cognitive Theory [11] to increase the girls' self-efficacy for physical activity [12]. The LEAP intervention was organized according to the Coordinated School Health Program (CSHP) model [25,26]. Six of eight components from the CSHP model were included in project LEAP: physical education, school environment, health education, school health services, faculty or staff health promotion, and parent and community involvement. The intervention staff assisted teachers in the intervention schools who then developed curricula designed to help adolescent girls (1) enhance physical activity self-efficacy through successful experiences with physical activity both inside and outside of school and (2) develop physical and behavioral skills necessary to adopt a physically active lifestyle during the teenage years and to maintain it through adulthood. Teachers at each school developed behavioral skill instructional units that emphasized the acquisition and practice of self-regulatory behaviors (e.g., goal setting, time management, identifying and overcoming barriers, and self-reinforcement); the units were implemented in health education, biology, family and consumer science, or physical education, depending upon how each school provided health education. The LEAP physical education component, known as LEAP PE, included a 1-year curriculum designed by the teachers at each school to develop motor skills in a variety of physical activities that were popular with high-school girls including aerobics, weight training, dance, and self-defense using approaches that favored small groups and cooperative and successful learning experiences. In addition to facilitating noncompetitive mastery of skills, the instruction also used modeling of success, encouragement, and moderately intense exercise directed toward enhancing self-efficacy.

Control

Schools in the control condition did not receive an intervention. However, most students in the control schools completed a full academic year of standard physical education as mandated by the state of South Carolina.

Data analysis

Data were analyzed in two steps. The first step involved testing the multigroup and longitudinal factorial invariance of the questionnaires using confirmatory factor analysis (CFA). The second step involved testing the effect of the intervention on presumed mediators of change in physical activity using latent variable structural equation modeling (LVSEM).

Factorial invariance

We tested the multigroup and longitudinal factorial invariance of the questionnaires because nonequivalent measurement operations can confound the interpretation of research findings [27,28] when the effect of an intervention (e.g., experimental vs. control groups) on longitudinal changes in constructs is assessed using self-report measures [29]. As an example, if the intervention influenced the students' interpretation of the questionnaires and not the actual constructs per se, then the observed effects of the intervention on questionnaire scores could be misattributed to a treatment effect. The analyses of multigroup and longitudinal factorial invariance involved comparing nested models that imposed successive restrictions on model parameters for the equality of the overall structure, factor loadings, factor variances, and item uniquenesses using standard procedures [18,28] reported elsewhere [19,20]. The analysis of longitudinal factorial invariance involved a single-group, two-factor correlated measurement model with autocorrelations specified between uniquenesses of identical indicators of the single factor model at baseline and at follow-up.

Confirmatory factor analysis

Tests of factorial invariance were undertaken using CFA with full-information maximum likelihood (FIML) estimation in AMOS 4.0 (SmallWaters Corp., Chicago, IL) [30]. FIML was selected because there were missing responses to items on the questionnaires. FIML is an optimal method for the treatment of missing data in LVSEM [30,31] that has yielded accurate fit indices with simulated missing data [32,33]. The size of the sample was adequate to estimate the models [34].

Model fit

Model fit was assessed using multiple indices. The χ^2 test statistic assessed the absolute fit of the model to the data, but it is sensitive to sample size [35–37]. The root mean square error of approximation (RMSEA) represents closeness of fit, and values approximating 0.06 and zero demonstrate close and exact fit of the model, respectively [38,39]. The 90% confidence interval (CI) around the RMSEA point estimate should also contain 0.06 or zero to indicate close or exact fit, respectively. The Comparative Fit Index (CFI) and Non-Normed Fit Index (NNFI) test the proportionate improvement in fit by comparing the target model with the independence model [41,42]. Minimally acceptable fit was based on CFI and NNFI values of 0.90 [40,41]; values approximating 0.95 indicated good fit [39]. The parameter estimates, standard errors, z statistics, and squared multiple correlations were inspected for appropriate sign or magnitude. Parameters with nonsignificant z

[1] Detailed descriptions of the components and process evaluation of the LEAP intervention are available from the corresponding author.

statistics or a sign opposite of the expected direction have no substantively meaningful interpretation [36]. A large standard error indicates that a parameter estimate is not reliable.

Latent variable structural equation modeling

The LVSEM was performed using FIML estimation in AMOS 4.0 [30]. The entire sample of adolescent girls was adequate to estimate the structural model [34].

Model specification

The individual measurement models for the measures of self-efficacy, outcome-expectancy value, goal setting, and physical activity were specified to be unidimensional. The single item measure of satisfaction was modeled as an observed variable. As seen in Fig. 2, the structural model included (1) paths between latent variables assessed before and after the intervention [44]; (2) paths from self-efficacy, outcome-expectancy value, goal setting, and satisfaction to PA; and (3) a path between the intervention and the measures of self-efficacy, outcome-expectancy value, goal setting, satisfaction, and PA assessed after the intervention. The intervention was coded as control (0), low implementation (1), and high implementation (2) groups. There were correlations between self-efficacy, outcome-expectancy value, goal setting, and satisfaction exogenous latent variables at time 1, and correlations between error terms for the self-efficacy, outcome-expectancy value, goal setting, and satisfaction endogenous variables at time 2. There were also correlations among the uniquenesses of identical items across time [42].

Model fit

Model fit was assessed using the χ^2 test statistic and the aforementioned guidelines for the RMSEA point estimate and 90% CI, CFI, and NNFI values. The parameter estimates, standard errors, z scores, and squared multiple correlations were inspected for appropriate sign or magnitude.

Results

The confirmatory factor analyses of responses to the questionnaires supported multigroup and longitudinal factorial invariance, indicating that the measures were equiv-

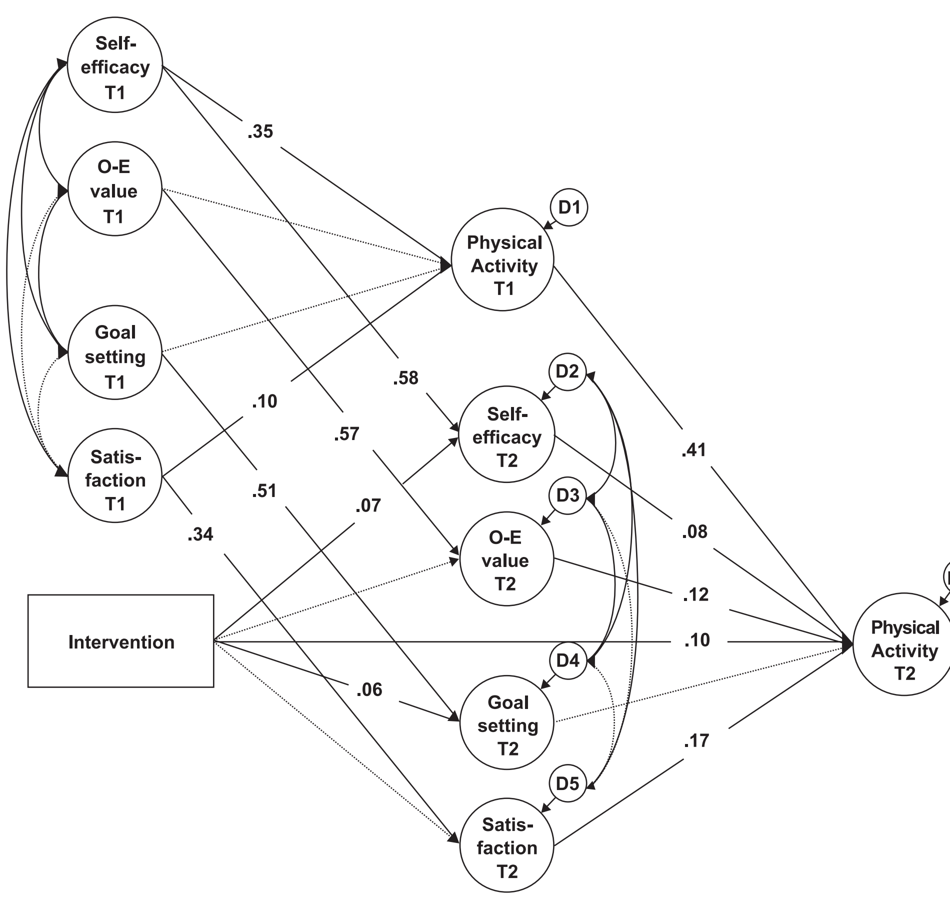

Fig. 2. Model depicting the effects of intervention on changes in primary cognitive processes within the social cognitive theory and physical activity. O–E value represents outcome-expectancy value. T1 represents baseline. T2 represents follow-up. Broken lines indicate nonsignificant paths. D1–D6 represent disturbance terms.

alent between the control and intervention groups across the 1-year study period.[2]

Multigroup factorial invariance

The measurement model for the measures of self-efficacy, outcome-expectancy value, and goal setting each consisted of a single factor and demonstrated good fit in the control and intervention groups. Each of the four nested models demonstrated good fit, and successive comparisons of the nested models indicated that the factor structure, factor loadings, factor variances, and item uniquenesses were invariant between groups.

The measurement model for the measure of physical activity consisted of a single factor and fit perfectly in the control and intervention groups. Comparisons of the nested models indicated that the factor structure, factor loadings, factor variances, but not item uniquenesses, were invariant between groups.

Longitudinal factorial invariance

Self-efficacy

The factor structure, factor loadings, and factor variances, but not the item uniquenesses, were invariant across time in the control and intervention groups, respectively. The stability coefficient for self-efficacy across the 1-year study period was 0.58.

Outcome-expectancy value

The analysis indicated good fit in each of the four nested models. The factor structure, factor loadings, factor variances, and item uniquenesses were invariant across time. The stability coefficient for outcome-expectancy value across the 1-year study period was 0.57.

Goal-setting

The analysis indicated good fit for each of the four nested models. The factor structure, factor loadings, factor variances, and item uniquenesses were invariant across time. The stability coefficient for goal setting across the 1-year study period was 0.51.

Physical activity

The factor structure and factor loadings were not invariant across time, so we tested a model with partially invariant factor loadings [44] by removing the invariance constraint on the indicator for weekend physical activity. Subsequent analysis indicated that the factor structure and factor loadings of the respecified model were partially invariant across time in each group. Factor variances were invariant across time in the intervention group but not in the control group. Item uniquenesses were not invariant across time in either group. The stability coefficient for physical activity across the 1-year study period was 0.41.

Latent variable structural equation modeling

We tested the model depicted in Fig. 2 using LVSEM. The model represented an acceptable fit (χ^2 = 3389.98, df = 1273, RMSEA = 0.028 [90% CI = 0.027–0.029], CFI = 0.905, NNFI = 0.900).[3] Initially, we inspected the path coefficients for the relationships between theoretical constructs and physical activity. There were significant relationships from self-efficacy and satisfaction to physical activity at baseline. At follow-up, there were significant relationships from self-efficacy, outcome-expectancy value, and satisfaction to physical activity. The magnitude of the relationship between satisfaction and physical activity was larger at follow-up than at baseline. The relationship between self-efficacy and physical activity was smaller at follow-up than at baseline.

We then inspected the path coefficients between the same latent variables across time (e.g., path coefficient between physical activity from before to after the intervention). As expected with self-report measures of psychological constructs, the magnitude of the path coefficients between the same latent variables across time ranged between 0.34 and 0.58. Hence, there was some degree of change in the relative rank ordering of participants on scores from the measures across the year.

Most importantly, we inspected the path coefficients in Fig. 2 to identify the effect of the intervention on mediator variables. The intervention had statistically significant, but small direct effects on self-efficacy, goal setting, and physical activity. Self-efficacy, outcome-expectancy value, and satisfaction had statistically significant direct effects on physical activity. Thus, the effect of the intervention on physical activity was partially mediated by self-efficacy.

[2] Tables summarizing the factorial invariance analyses are available upon request from the corresponding author.

[3] Because of the large number of degrees-of-freedom with 53 observed variables in the structural model, we tested the fit of a similar, but smaller, model using parcels [45–47] for the indicators on the unidimensional measures of self-efficacy, outcome-expectancy value, and goal setting. This was necessary because the Monte Carlo research has indicated that as the number of indicators per factor increases, there are concomitant decreases in the value of many commonly employed fit indices [48,49]. The parcels were formed by summing scores from pairs of indicators on each measure based on previously published methodology [47]. The smaller structural model represented an improved and good fit to the data (χ^2 = 1103.75, df = 393, RMSEA = 0.029 [90% CI = 0.027–0.031], CFI = 0.951, NNFI = 0.941). Nonetheless, the parsimony CFI and NNFI values (e.g., PNNFI = NNFI [degrees-of-freedom for the substantive model / degrees-of-freedom for null model] [50] were better for the larger model (PCFI = 0.836; PNNFI = 0.831) than the smaller model with item parcels (PCFI = 0.804; PNNFI = 0.795). Moreover, the magnitude and direction of the path coefficients from the smaller model with parcels did not differ from those obtained with the larger structural model. Hence, we believe the large structural model represents a good fit to the data, with clearly interpretable path coefficients, despite the observed fit indices meeting minimally acceptable standards.

In a secondary analysis, we tested whether the mediator effect of self-efficacy was influenced by school using a standard, three-step mixed model regression procedure [43]. First, we regressed the postintervention physical activity scores on the intervention variable while controlling for baseline physical activity and the nested effect of school within the intervention groups. Next, we repeated that model, substituting self-efficacy for physical activity. Finally, we repeated the first step, adding the postintervention self-efficacy score to the initial regression model. Results indicated effects of the intervention on physical activity ($F(2,21) = 4.39$, $P = 0.02$) and self-efficacy ($F(2,21) = 3.51$, $P = 0.05$). The intervention effect on physical activity was attenuated, but remained statistically significant ($F(2,21) = 3.88$, $P = 0.04$), with the addition of self-efficacy. Thus, the results extend the SEM analysis, indicating that the partial mediation effect of self-efficacy was not confounded by school.

Discussion

The primary novel finding of the study is that self-efficacy partially mediated the effect of the LEAP intervention on physical activity among adolescent black and white girls. In addition to its direct effect on physical activity, the intervention had a direct effect on self-efficacy which had a subsequent direct effect on physical activity. To our knowledge, we have provided in this report the first and only experimental evidence showing that increased self-efficacy directly results in increased physical activity among adolescent girls. In addition, the prospective prediction of physical activity by self-efficacy, independent of the experimental intervention, extends prior correlational evidence that prospectively linked self-efficacy with physical activity among 5th grade girls [51]. Hence, collective evidence encourages the use of self-efficacy as a mediator variable in interventions designed to increase physical activity among adolescent black and white girls.

The effects of intervention on self-efficacy ($\Gamma_{25} = 0.07$) and self-efficacy on physical activity ($\beta_{62} = 0.08$) are similar in magnitude to those reported by other investigators who have studied social-cognitive correlates of physical activity among the youth [8–10]. Though small in size when judged against conventional guideposts for sample statistics [52], the observed direct and mediated effects of the intervention are equivalent to increasing physical activity among four girls per 100 [53], an effect that would be practically meaningful in the population.

A special feature of our analysis was the use of process evaluation of the fidelity of each school's implementation of the LEAP intervention components for the purpose of categorizing the schools according to their level of implementation. Process evaluation has rarely been included in prior reports of school-based physical activity interventions [54], but our results illustrate the utility of assessing intervention fidelity [55] in the evaluation of a physical activity intervention's impact. They indicate that the observed effects underestimate the potential efficacy of the intervention had it been fully implemented by all the schools in the intervention arm of the experiment. Our findings further suggest that the lack of success in increasing leisure-time physical activity reported previously by many school-based interventions might be partly explained by inadequate implementation of the intervention components.

An increase in self-efficacy was a cornerstone objective of the LEAP intervention. Consistent with Social Cognitive Theory's concept of reciprocal determinism of personal, behavioral, and environmental influences on physical activity, LEAP included both environmental and curricular (especially LEAP PE) components specifically designed to enhance the girls' self-efficacy for physical activity. Nonetheless, given the multifactorial nature of the LEAP intervention and the complexity of other factors that influence self-efficacy beliefs and physical activity, the effects observed may underestimate the potential impact of interventions that focus on self-efficacy. Another focus of the LEAP intervention was the development of behavioral skills such as goal setting needed to adopt a healthy lifestyle. We found that there was a significant effect of the intervention on goal setting, but goal setting was unrelated to changes in physical activity. Moreover, goal setting did not exhibit a cross-sectional relationship with physical activity in the baseline data. Hence, the establishment of goals does not appear to be an important influence of physical activity among adolescent girls, as measured in the present study.

There were differential effects of the primary cognitive processes within SCT on physical activity. Self-efficacy and satisfaction were consistently related to physical activity, outcome-expectancy value was related to physical activity only at follow-up, and goal setting was not significantly related to physical activity. The lack of a consistent direct effect of outcome-expectancy value on physical activity agrees with previous research [17] and suggests that imagined incentives for being physically active are weak determinants among girls. We are unaware of any cross-sectional, prospective, or experimental studies providing evidence linking goal setting with physical activity among adolescent girls. Our results provide initial support for self-efficacy and satisfaction as the primary cognitive processes from SCT that predict physical activity among adolescent girls.

We tested the multigroup and longitudinal factorial invariance of the measures in the present study before examining the effect of the intervention. This was important because nonequivalent measurement operations can confound the interpretation of research findings when the effects of an intervention (e.g., experimental vs. control groups) on longitudinal changes in constructs are measured by self-report questionnaires. The measures of self-efficacy, outcome-expectancy value, and goal setting exhibited invariance of the factor structure and factor loadings between the groups and across the 1-year period of the LEAP PE intervention. The measure of physical activity exhibited invariance of the factor structure and factor loadings between groups, and partial invariance of factor loadings across the year. Thus, the intervention did not influence the interpretation of the questionnaires, but rather the actual latent constructs. Hence, the observed effects of the intervention are correctly attributed to a treatment effect rather than nonequivalent measurement operations.

The structural model supported the stability of the measures of self-efficacy, outcome-expectancy value, goal setting, satisfaction, and physical activity. The magnitude of the path coefficients between the same social-cognitive constructs across time was moderately high (0.51–0.58), except for satisfaction (0.34), which was indicated by a single item. The stability coefficient for physical activity (0.41) compares favorably to stability estimates of physical activity assessed by other self-report measures of physical activity and objective motion sensors over shorter periods of time [56]. These results, in combination with longitudinal invariance analyses, indicate that the measures exhibited stationarity and stability. Stationarity demonstrates that the same construct is being measured across time. Stability demonstrates that the relative rank ordering of participants on the construct remains constant across time. An objective measure of physical activity would add concurrent evidence for the validity of the self-report of physical activity used in the present study. Nonetheless, the present evidence of the factorial invariance and stability of the 3-Day Physical Activity Recall, coupled with our prior accelerometry study [24] showing its positive relationship with an objective measure of physical activity, gives us confidence that the effects on physical activity that we report are real.

We recommend that future interventions designed to increase physical activity among adolescent girls target self-efficacy as a mediator variable. Self-efficacy can be influenced by reinforcement history, observational learning, persuasion, and perceived exertion [12]. Thus, future research is needed to identify how those influences can be optimally incorporated into interventions that will increase the girls' self-efficacy beliefs about their ability to be physically active. Ways by which self-efficacy regulates thoughts and behaviors that prompt and reinforce physical activity among girls also require study.

Acknowledgment

Supported by NIH HL 57775 from the National Heart, Lung and Blood Institute.

References

[1] Centers for Disease Control and Prevention. Youth risk behavior surveillance—United States, 1997. MMWR 1998;47(SS-3):1–89.

[2] Sallis JF, Patrick K. Physical activity guidelines for adolescents: consensus statement. Pediatr Exerc Sci 1994;6:302–14.

[3] Sallis JF, Simons-Morton BG, Stone EJ, Corbin CB, Epstein LH, Faucette N, et al. Determinants of physical activity and interventions in youth. Med Sci Sports Exerc 1992;24:S248–57.

[4] Dishman RK, Buckworth J. Increasing physical activity: a quantitative synthesis. Med Sci Sports Exerc 1996;28:706–19.

[5] Stone EJ, McKenzie TL, Welk GJ, Booth ML. Effects of physical activity interventions in youth. Review and synthesis. Am J Prev Med 1998;15:298–315.

[6] Baranowski T, Anderson C, Carmack C. Mediating variable framework in physical activity interventions. How are we doing? How might we do better? Am J Prev Med 1998;15:266–97.

[7] Lewis BA, Marcus BH, Pate RR, Dunn AL. Psychosocial mediators of physical activity behavior among adults and children. Am J Prev Med 2002;23(2S):26–35.

[8] Edmundson E, Parcel GS, Feldman HA, Elder J, Perry CL, Johnson CC, et al. The effects of the child and adolescent trial for cardiovascular health upon psychosocial determinants of diet and physical activity. Prev Med 1996;25:442–54.

[9] Nader PR, Stone EJ, Lytle L, Perry CL, Osganian SK, Kelder S, et al. Three-year maintenance of improved diet and physical activity, the CATCH cohort. Arch Pediatr Adolesc Med 1999;153:695–704.

[10] Parcel GS, Simons-Morton B, O'Hara NM, Baranowski T, Wilson B. School promotion of healthful diet and physical activity: impact on learning outcomes and self-reported behavior. Health Educ Q 1989; 16:181–99.

[11] Bandura A. Social foundations of thought and action. Englewood Cliffs, NJ: Prentice-Hall; 1986.

[12] Bandura A. Self-efficacy: the exercise of control. New York, NY: Freeman; 1997.

[13] Bandura A. Social learning theory. Englewood Cliffs, NJ: Prentice-Hall; 1977.

[14] Edwards W. The theory of decision making. Psychol Bull 1954; 51:380–417.

[15] Feather NT. Expectations and actions: expectancy value models in psychology. Hillsdale, NJ: Lawrence Erlbaum; 1982.

[16] Rotter JB. Some implications of a social learning theory for the prediction of goal directed behavior from testing procedures. Psychol Rev 1960;67:301–16.

[17] Sallis JF, Prochaska JJ, Taylor WC. A review of correlates of physical activity of children and adolescents. Med Sci Sports Exerc 2000; 32:963–75.

[18] Motl RW, Dishman RK, Ward DS, Saunders RP, Dowda M, Felton G, et al. Examining social-cognitive determinants of intention and physical activity among black and white adolescent girls using structural equation modeling. Health Psychol 2002;21:459–67.

[19] Dishman RK, Motl RW, Saunders RP, Dowda M, Felton G, Ward DS, et al. Factorial invariance and latent mean structure of questionnaires measuring social-cognitive determinants of physical activity among black and white adolescent girls. Prev Med 2002;34:100–8.

[20] Motl RW, Dishman RK, Trost SG, Saunders RP, Dowda M, Felton G, et al. Factorial validity and invariance of questionnaires measuring social-cognitive determinants of physical activity in adolescent girls. Prev Med 2000;31:584–94.

[21] Ajzen I. The theory of planned behavior. Org Behav Human Decis Process 1991;50:179–211.

[22] Weston AT, Petosa R, Pate RR. Validity of an instrument for measurement of physical activity in youth. Med Sci Sports Exerc 1997; 29:138–43.

[23] Motl RW, Dishman RK, Saunders R, Dowda M, Felton G, Pate RR. Measuring enjoyment of physical activity among adolescent girls. Am J Prev Med 2001;21:110–7.

[24] Pate RR, Ross R, Dowda M, Trost SG, Sirard J. Validation of a three-day physical activity recall instrument in female youth. Pediatr Exerc Sci 2003;15(3):257–65.

[25] Allensworth DD, Kolbe LJ. The comprehensive school health program: exploring an expanded concept. J Sch Health 1987;57:409–12.

[26] Davis TM, Allensworth DD. Program management: a necessary com-

ponent for the comprehensive school health program. J Sch Health 1994;64:400–4.
[27] Aiken LS, West SG. Invalidity of true experiments: self-report pretest biases. Eval Res 1990;14:374–90.
[28] Pitts SC, West SG, Tein J. Longitudinal measurement models in evaluation research: examining stability and change. Eval Program Plann 1996;19:333–50.
[29] Horn JL, McArdle JJ. A practical and theoretical guide to measurement invariance in aging research. Exp Aging Res 1992;18:117–44.
[30] Arbuckle JL, Wothke W. Amos 4.0 user's guide. Chicago, IL: SmallWaters; 1999.
[31] Wothke W. Longitudinal and multigroup modeling with missing data. In: Little TD, Schnabel KU, Baumert J, editors. Modeling longitudinal and multilevel data: practical issues, applied approaches, and specific examples. Mahwah, NJ: Lawrence Erlbaum; 2000. pp. 219–40.
[32] Arbuckle JL. Full information estimation in the presence of incomplete data. In: Marcoulides GA, Schumacker RE, editors. Advanced structural equation modeling: issues and techniques. Mahwah, NJ: Lawrence Erlbaum; 1996. pp. 243–77.
[33] Enders CK, Bandalos DL. The relative performance of full information maximum likelihood estimation for missing data in structural equation models. Struct Equ Modeling 2001;8:430–57.
[34] Jackson DL. Sample size and number of parameter estimates in maximum likelihood confirmatory factor analysis: a Monte Carlo investigation. Struct Equ Modeling 2001;8:205–23.
[35] Bollen KA. Structural equations with latent variables. New York, NY: Wiley; 1989.
[36] Jöreskog KG. Testing structural equation models. In: Bollen KA, Long JS, editors. Testing structural equation models. Newbury Park, CA: Sage Publications; 1993. pp. 294–316.
[37] Jöreskog KG, Sörbom D. LISREL 8: user's reference guide. Chicago, IL: Scientific Software International; 1996.
[38] Browne MW, Cudeck R. Alternative ways of assessing model fit. In: Bollen KA, Long JS, editors. Testing structural equation models. Newbury Park, CA: Sage, 1993; pp. 136–62.
[39] Hu L, Bentler PM. Cutoff criteria for fit indices in covariance structure analysis: conventional criteria versus new alternatives. Struct Equ Modeling 1999;6:1–55.
[40] Bentler PM, Bonett DG. Significance tests and goodness of fit in the analysis of covariance structures. Psychol Bull 1980;88:588–606.
[41] Bentler PM. Comparative fit indices in structural models. Psychol Bull 1990;107:238–46.
[42] Kessler RC, Greenberg DF. Linear panel analysis: models of quantitative change. New York, NY: Academic Press; 1981.
[43] Eisen M, Zellman GL, Murray DM. Evaluating the lions-quest "Skills for Adolescence" drug education program: second-year behavior outcomes. Addict Behav 2003;28:883–97.
[44] Byrne BM, Shavelson RJ, Muthén B. Testing for the equivalence of factor covariance and mean structures: the issue of partial measurement invariance. Psychol Bull 1989;105:456–66.
[45] Bagozzi RP, Edwards JR. A general approach for representing constructs in organizational research. Organ Res Methods 1998;1:45–87.
[46] Bandalos DL. The effects of item parceling on goodness-of-fit and parameter estimate bias in structural equation modeling. Struct Equ Modeling 2002;9:78–102.
[47] Hall RJ, Snell AF, Foust MS. Item parceling strategies in SEM: investigating the subtle effects of unmodeled secondary constructs. Organ Res Methods 1999;2:233–56.
[48] Anderson JC, Gerbing DW. The effect if sampling error on convergence, improper solutions, and goodness-of-fit indices for maximum likelihood confirmatory factor analysis. Psychometrika 1984;49:155–72.
[49] Ding L, Velicer WF, Harlow LL. Effects of estimation methods, number of indicators per factor, and improper solutions on structural equation modeling fit indices. Struct Equ Modeling 1995;2:119–44.
[50] Muliak SA, James LR, Van Alstine J, Bennett N, Lind S, Stillwell CD. An evaluation of goodness of fit indices for structural equation models. Psychol Bull 1989;105:430–45.
[51] Trost SG, Pate RR, Saunders R, Ward DS, Dowda M, Felton G. A prospective study of the determinants of physical activity in rural fifth-grade children. Prev Med 1997;26:257–63.
[52] Cohen J. Statistical power analysis for the behavioral sciences. 3rd edition. New York, NY: Academic Press; 1988.
[53] Rosenthal R, Rubin DB. A simple, general purpose display of magnitude of experimental effect. J Educ Psychol 1982;74:166–9.
[54] McGraw SA, Sellers DE, Stone EJ, Bebchuk J, Edmundson EW, Johnson CC, et al. Using process data to explain outcomes. An illustration from the Child and Adolescent Trial for Cardiovascular Health (CATCH). Eval Rev 1996;20:291–312.
[55] Glasgow RE, Vogt TM, Boles SM. Evaluating the public health impact of health promotion interventions: the RE-AIM framework. Am J Publ Health 1999;89:1323–7.
[56] Sirard JR, Pate RR. Physical activity assessment in children and adolescents. Sports Med 2001;31:439–54.